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Local Evolution and Global Annihilation of the Shallow and Deep Structures of the Universe 2024v 1.2

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The Structure and Evolution of the Universe: Hierarchies, Dynamics, and the Significance of Life from the Visible Domain of Hundreds of Billions of Light - Years to Invisible Spacetime | 10 Chapters in Total | Abstract: This study takes the visible universe on the scale of hundreds of billions of light - years as the observational basis and the invisible cosmic domain as the theoretical extension to systematically construct a theoretical system of hierarchical evolution of the cosmic structure. The paper strictly distinguishes between shallow and deep structures, local evolution and overall laws, material aggregation and fission, and spacetime dynamics. It covers all celestial bodies and material forms such as supergiants, extreme black holes, dark matter, dark energy, cosmic filaments, galaxy clusters, and interstellar medium, and deeply explores the full - life - cycle mechanisms of structure formation, stability, decay, annihilation, explosion, and recombination. At the same time, the paper introduces interdisciplinary methods from astrophysics, astrochemistry, particle physics, and quantum chemistry to analyze the cosmic elemental abundance, the commonalities of multi - dimensional structures, and the laws of order - chaos transformation. It also makes scientific judgments on the cosmic life threshold, the necessity and contingency of the origin of life, and the evolutionary positioning of the solar system and the Milky Way. The research ultimately proves that the universe has extremely strong breadth, depth, and non - intuitiveness in terms of scale, matter, spacetime, and evolutionary paths. The visible universe is only a tiny fragment of the overall structure, and the scale and complexity of the invisible structure far exceed the existing observations and theoretical estimates. This study forms a complete framework for cosmic structural evolution, providing theoretical support for the unified theory of cosmic - scale structures and micro - particles, the search for extraterrestrial life, and the study of extreme astrophysics.

Keywords: cosmic structure; cosmic evolution; visible universe; invisible universe; dark matter; dark energy; extreme celestial bodies; structural annihilation; life threshold; cosmic evolutionary science

Chapter 1 Introduction: The Scale Boundaries, Structural Complexity, and Scientific Issues of the Universe

1.1 Research Background: From the Visualization of Hundreds of Billions of Light - Years to the Boundaries of Cosmic Cognition

Human observation of the universe has entered the visible scale of hundreds of billions of light - years. With the help of devices such as the James Webb Space Telescope, Planck Satellite, LIGO gravitational wave detector, and Large Hadron Collider, humans can directly observe hundreds of trillions of celestial bodies and structures such as galaxies, stars, planets, nebulae, pulsars, supergiants, black holes, and quasars. However, observational data also reveal that visible matter accounts for only about 5% of the total mass - energy of the universe, dark matter about 27%, and dark energy about 68%. Most of the universe's structures are in an invisible state.

Are there continuous spacetimes outside the visible universe? Do there exist galaxies, black holes, dark matter clumps, and superstructures in the invisible regions? Are the existing physical laws still applicable? These questions constitute the core unsolved mysteries of modern cosmology. The universe is not a uniform, simple, and linear physical system, but presents complex characteristics of hierarchy, localization, dynamics, and circulation. Its structural evolution spans the entire time scale from the primordial inflation to the late - stage decay of the universe.

1.2 Domestic and Foreign Research Status

Modern cosmology uses the Λ CDM model as the standard framework to explain cosmic expansion, structure formation, and the effects of dark matter and dark energy. On the large - scale structure, the universe presents typical forms such as filamentary structures, galaxy clusters, superclusters, and giant voids. In the field of extreme celestial bodies, the engine mechanisms of stellar - mass black holes, supermassive black holes, supergiants, extremely luminous infrared galaxies, and gamma - ray bursts have been continuously confirmed by observations.

However, existing research still has three major gaps:

1. It has not strictly distinguished the evolutionary paths and destruction mechanisms of shallow and deep structures.
2. There is a lack of systematic theoretical modeling for the structural scale, distribution, and physical laws outside the visible universe.
3. The cross - logic among cosmic structural evolution, particle structure, and the origin of life has not formed a unified system.

1.3 Research Significance

Theoretical significance: Establish a complete framework for cosmic structural evolution science, unify the laws of cosmic - scale, macro, and micro structures, and improve the theories of cosmic hierarchical evolution, local explosions, and structural annihilation. Practical significance: Provide a basis for determining the habitable zone of extraterrestrial life, predicting the evolution of the solar system, studying high - energy astrophysics, and verifying quantum gravity theories.

1.4 Research Content and Methods

The research takes eight core aspects, including hierarchical structure, evolutionary dynamics, destruction mechanisms, local perturbations, material

interactions, life thresholds, interdisciplinary integration, and cosmic abundance, as the main lines. It adopts methods such as observational data analysis, numerical simulation, theoretical derivation, comparative cosmology, and interdisciplinary verification to complete the research on the evolution of the cosmic structure on all scales.

1.5 Thesis Structure and Innovation Points

The thesis has 10 chapters, covering a complete system from the visible universe to the invisible universe, from celestial aggregation to the origin of life, and from physical laws to chemical foundations. The innovation points include: proposing a binary structure model of cosmic shallow - deep structures; establishing a theory of the full - life - cycle evolution of structures; constructing a quantitative system for the cosmic life threshold; and completing the comparative estimation of the structural scales of the visible and invisible universes.

Chapter 2 The Scale and Material Composition of the Universe: The Basis for Visualizing the Hundreds of Billions of Light - Years of the Visible Universe

2.1 The Scale Definition and Observational Boundary of the Visible Universe

The visible universe is constrained by the speed of light propagation and the age of the universe, with a diameter of about 93 billion light - years. Within this field of view, humans can achieve direct or indirect visual observation through electromagnetic radiation, gravitational waves, and neutrinos. This scale is not the real boundary of the universe but the boundary of the observational horizon.

2.2 The Hierarchy and Order of Magnitude of the Cosmic Celestial System

Cosmic celestial bodies show a strict hierarchical distribution: planet - star - star cluster - galaxy - galaxy cluster - supercluster - cosmic filament. The observable universe contains about a trillion galaxies, each with an average of 100 billion stars, and the total number of celestial bodies reaches the order of hundreds of trillions to quadrillions.

The main types of celestial bodies include:

- Regular celestial bodies: planets, satellites, asteroids, comets, main - sequence stars, red dwarfs;
- Giant and extreme stars: blue supergiants, red supergiants, Wolf - Rayet stars, supernovae;
- Compact celestial bodies: white dwarfs, neutron stars, pulsars, magnetars, stellar - mass black holes;
- Supermassive celestial bodies: supermassive black holes at the center of galaxies, quasars, active galactic nuclei;
- Interstellar matter: gas, dust, molecular clouds, ionized hydrogen regions, interstellar medium.

2.3 The Mass - Energy Composition of the Universe: Visible Matter, Dark Matter, and Dark Energy

Visible matter is composed of atoms, participates in electromagnetic interactions, and can be directly observed; dark matter only participates in gravitational and weak interactions and maintains the stability of galaxy structures; dark energy drives the accelerated expansion of the universe and

dominates the late - stage fate of the universe. The three together determine the formation, evolution, and final destiny of the cosmic structure.

2.4 Beyond the Visible Universe: The Theoretical Existence of Invisible Structures

The invisible universe includes the universe outside the horizon, high - dimensional spacetime, dark matter - dominated regions, and extreme spacetime regions. Its structural scale, number of celestial bodies, and material distribution cannot be directly observed, but their existence can be inferred indirectly through cosmic uniformity, inflation theory, gravitational perturbations, etc. From the deduction of logic and physical laws, the total amount of structures in the invisible universe is much larger than that in the visible universe.

2.5 The Core Characteristics of the Cosmic Structure: Vastness, Depth, Non - Intuitiveness, and Hierarchy

The cosmic structure does not have simple intuitiveness, and its laws cannot be directly derived from daily experience. It must rely on interdisciplinary integration and physics under extreme conditions to be gradually revealed.

Chapter 3 The Composition, Formation, and Evolution of Cosmic Shallow Structures

3.1 The Definition and Scope of Shallow Structures

Shallow structures refer to cosmic structures that can be directly observed, are in short - range, have a regular gravitational environment, and are dominated by visible matter, including the solar system, stellar systems, galaxies, galaxy clusters, nebulae, regular celestial bodies, interstellar dust, and gas.

3.2 The Formation Mechanism of Shallow Structures

Shallow structures are formed by the collapse, cooling, fragmentation, and aggregation of primordial gas clouds under the action of gravity. Stars form from the collapse of molecular clouds, planets form from the accretion of protoplanetary disks, galaxies form from the capture of baryonic matter by dark matter halos, and galaxy clusters continue to grow through galaxy mergers and material accretion.

3.3 The Evolutionary Stages of Shallow Structures

1. Primordial perturbations and structural nucleation;
2. Gravitational collapse and celestial body formation;
3. Stable evolution and energy output;
4. Material exchange and dynamic interaction;
5. Aging, instability, and structural decline.

3.4 The Motion Modes of Shallow Structures: Rotation, Revolution, Hyperrotation, and Gravitational Interaction

Rotation and hyperrotation are the most common motion forms of shallow structures. Galaxies, stars, planets, and black hole accretion disks all show vortex structures. Gravitational interaction drives mergers, $\ddot{}$ ing, material transfer, and orbital perturbations, which are the core driving forces of structural evolution.

3.5 The Order and Stability of Shallow Structures

Shallow structures show a high degree of order under the balance of gravity, angular momentum, and pressure, but they will enter a short - term chaotic state during mergers, eruptions, and γ - ray events, and then re - achieve stability.

Chapter 4 The Composition, Formation, and Evolution of Cosmic Deep Structures

4.1 The Definition and Scope of Deep Structures

Deep structures include large - scale cosmic structures, invisible matter structures, extreme - density celestial bodies, multi - dimensional spacetime structures, and particle - based structures, such as cosmic walls, giant voids, dark matter halos, supermassive black holes, dark energy fields, and quantum spacetime structures.

4.2 The Physical Drivers of Deep Structures: Inflation, Dark Matter, and Dark Energy

Cosmic inflation generates primordial density fluctuations, which become the seeds of all structures; dark matter provides gravitational anchors and determines the large - scale framework; dark energy promotes spatial expansion and inhibits the formation of small - scale structures. The three together shape deep structures.

4.3 The Evolutionary Laws of Deep Structures

The evolution of deep structures is slower, more stable, and more global, and at the same time has extreme physical conditions. Supermassive black holes continue to grow through accretion and mergers; dark matter halos form the framework of cosmic filaments; dark energy gradually dominates cosmic expansion, causing large - scale structures to eventually disperse.

4.4 The Coupling Relationship Between Deep Structures and Shallow Structures

Deep structures are the carriers and constraints of shallow structures, and shallow structures are the visible manifestations of deep structures. Galaxies are born in dark matter halos, stars form in high - density regions of cosmic filaments, and extreme celestial activities affect the distribution of large - scale gas.

4.5 The Non - Classical Laws of Deep Structures

Deep structures involve non - classical physics such as quantum gravity, spacetime curvature, vacuum energy, and particle annihilation, which cannot be completely described by Newtonian mechanics and must be explained by general relativity, quantum field theory, and particle physics together.

Chapter 5 The Destruction, Annihilation, and Disappearance Mechanisms of Cosmic Structures (Unification of Shallow and Deep Structures)

5.1 The Destruction Modes of Shallow Structures

1. The end of stellar evolution: cooling of white dwarfs, slowing rotation of neutron stars, supernova explosions;
2. Destruction of planetary systems: collisions, tidal tearing, stellar γ - ray events, orbital disintegration;
3. Galaxy - level dissipation: mergers, gas stripping, stellar escape, structural collapse;

4. Material cycle: The material after destruction returns to the interstellar medium and participates in the formation of a new generation of celestial bodies.

5.2 The Annihilation and Disappearance Mechanisms of Deep Structures

5. Black hole evaporation: Hawking radiation causes small black holes to eventually disappear, and supermassive black holes evaporate in the extremely late stage;

6. Dark matter annihilation and decay: Weakly Interacting Massive Particles annihilate to produce gamma rays, and some dark matter models have decay;

7. Disintegration of large - scale structures: Dark energy causes the universe to continue to expand, galaxy clusters are pulled apart, and cosmic filaments gradually dissipate;

8. Spacetime decay: theoretical models such as vacuum decay and spacetime instability in the late universe.

5.3 The Differences in Time Scales of Structural Destruction

The time scale of shallow structure destruction ranges from millions of years to hundreds of billions of years; the time scale of deep structure annihilation can reach 10^{10} to the power of dozens of years, far exceeding the age of the visible universe.

5.4 The Dialectical Relationship Between Destruction and Evolution

Structural destruction is not an end but a starting point for material circulation and structural recombination. The universe realizes long - term dynamic evolution through "formation - stability - destruction - re - formation".

Chapter 6 Local Evolution, Perturbations, and Explosive Events of Cosmic Structures

6.1 The Definition and Classification of Local Events

Cosmic local events refer to intense dynamic processes occurring within a small spacetime range, including evolution, mergers, eruptions, explosions, γ - ray emission, and material ejection.

6.2 Mild Evolution of Local Structures

Galaxy mergers, star formation outbursts, black hole accretion flares, gas cloud collisions, star cluster diffusion, etc.

6.3 Local Violent Explosions and Destruction Events

1. Supernova explosions: core - collapse type and thermonuclear explosion type;

2. Gamma - ray bursts: the most violent explosions in the universe, coming from the collapse of massive stars or the merger of binary compact objects;

3. Novae and bright novae: runaway thermonuclear explosions from white dwarf accretion;

4. Tidal disruption events: flares produced by stars being torn apart by black holes;

5. Starbursts and quasar activities: intense energy release in galactic nuclear regions.

6.4 The Impact of Local Events on the Overall Structure

Shock waves generated by local explosions compress gas clouds to trigger star formation; high - energy radiation changes the ionization state of the interstellar medium; merger events change galaxy morphology and orbits; the accumulation

of a large number of local events determines the overall evolutionary trend of the universe.

6.5 The Laws of Local Order - Chaos Transformation

Local events are key nodes for structures to enter chaos from order and re-establish order, and are important sources of the diversity of cosmic structures.

Chapter 7 Cosmic Structural Evolution Science: Unified Laws of Multi - Dimensional Hierarchies, Particle Structures, and Extreme Celestial Bodies

7.1 The Disciplinary Framework of Cosmic Structural Evolution Science

Cosmic structural evolution science takes structure formation, movement, interaction, evolution, decay, and recombination as the core, integrating cosmology, astrophysics, particle physics, quantum physics, and astrochemistry to form an independent interdisciplinary discipline.

7.2 The Laws of Cosmic Multi - Dimensional Hierarchical Structures

The universe presents a continuous hierarchy:

- Microscopic level: elementary particles, atomic nuclei, atoms, molecules;
- Macroscopic level: planets, stars, galaxies;
- Cosmic scale level: galaxy clusters, cosmic filaments, large - scale structures;
- Spacetime level: dimensions, inflation, vacuum, dark energy fields.

7.3 Super - giant Celestial Structures and Their Evolution

Focus on research: supergiants, supermassive black holes, super dark matter clumps, super dark energy regions, extreme quasars. Such celestial bodies determine the cosmic energy output, gravitational field distribution, and structural evolution direction.

7.4 The Commonalities and Characteristics of Macroscopic Structures and Microscopic Particles

Commonalities: rotational symmetry, aggregation effect, fission laws, energy transitions, field interactions;

Characteristics: cosmic scale is dominated by gravity, microscopic scale is dominated by strong, weak, and electromagnetic forces; macroscopic scale satisfies classical and relativistic laws, microscopic scale satisfies quantum laws.

7.5 The Evolutionary Relationship Between Interstellar Particles and Macroscopic Celestial Bodies

Interstellar dust, molecules, and plasmas are the raw materials for stars and planets, as well as the products of celestial explosions, forming the link of cosmic material circulation.

Chapter 8 The Aggregation, Fission, Interaction, and Order - Chaos Dynamics of Cosmic Matter

8.1 The Mechanism of Matter Aggregation and Fusion

Gravitational accretion, collision and merger, gas cooling, nebula collapse, protoplanetary disk growth, galaxy fusion.

8.2 The Mechanism of Matter Separation, Fission, and Explosion

Mass loss, shell ejection, binary separation, planetary fragmentation, stellar eruptions, black hole tidal tearing.

8.3 The Hyperrotation and Vortex Dynamics of Interstellar Structures

Vortex is the most common structural form in the universe, driven by the conservation of angular momentum and gravity together, and stable structures all have rotational symmetry.

8.4 The Conversion Conditions of Order, Disorder, and Chaotic Disorder

Gravity, angular momentum, pressure, and magnetic fields maintain order; energy input, intense collisions, explosions, and γ -ray heating lead to chaos; the system returns to order after relaxation.

8.5 The Laws of Energy Flow and Mass Exchange

The evolution of cosmic structures is essentially the redistribution of energy and mass. All celestial activities, structural changes, and explosion events follow the laws of mass - energy conservation and thermodynamics.

Chapter 9 The Cosmic Life Survival Threshold and the Necessity and Contingency of the Origin of Life

9.1 The Physicochemical Survival Threshold of Cosmic Life

1. Temperature threshold: the range where liquid water exists;
2. Radiation threshold: high - energy radiation does not damage biomolecules;
3. Elemental abundance threshold: sufficient heavy elements such as carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur;
4. Orbital stability threshold: a long - term habitable environment;
5. Atmosphere and magnetic field threshold: protecting the surface ecology.

9.2 The Natural Formation of Organic Matter in the Universe

Interstellar molecular $\square$ [illegible][illegible]

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8.5 暗物質與暗能量的觀測證據 9.1 宇宙微波背景輻射 1. 宇宙微波背景輻射 2. 宇宙微波背景輻射 3. 宇宙微波背景輻射 4. 宇宙微波背景輻射 5. 宇宙微波背景輻射 9.2 超新星與宇宙加速膨脹 9.3 超新星與宇宙加速膨脹 9.4 超新星與宇宙加速膨脹 9.5 超新星與宇宙加速膨脹 10.1 宇宙大爆炸 10.2 宇宙大爆炸 10.3 宇宙大爆炸 10.4 宇宙大爆炸 10.5 宇宙大爆炸 40 頁 1. Planck Collaboration. Planck 2018 results. VI. Cosmological parameters. A&A, 2020. 2. Peebles P. J. E. The Large-Scale Structure of the Universe. Princeton University Press, 1980. 3. Riess A. G., et al. Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant. AJ, 1998. 4. Bertone G., Hooper D. Particle Dark Matter: Evidence, Candidates and Constraints. Phys. Rept., 2010. 5. Caldwell R. R., Kamionkowski M. The Physics of Cosmic Acceleration. ARA&A, 2009. 6. Kippenhahn R., Weigert A. Stellar Structure and Evolution. Springer, 1990. 7. Hawking S. W. Particle Creation by Black Holes. Commun. Math. Phys., 1975. 8. Mo H. J., van den Bosch F. C., White S. D. M. Galaxy Formation and Evolution. Cambridge University Press, 2010. 9. Ehrenfreund P., Charnley S. B. Organic Molecules in the Interstellar Medium, Comets and Meteorites. ARAA, 2000. 10. Kolb E. W., Turner M. S. The Early Universe. Westview Press, 1990.

● 宇宙微波背景輻射的觀測證據 1.1 宇宙微波背景輻射的觀測證據 LIGO 觀測到的重力波事件 5% 27% 68% 1.2 宇宙微波背景輻射的觀測證據 Λ CDM 模型 1. 宇宙微波背景輻射的觀測證據 2. 宇宙微波背景輻射的觀測證據 3. 宇宙微波背景輻射的觀測證據 1.3 宇宙微波背景輻射的觀測證據 1.4 宇宙微波背景輻射的觀測證據

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 2.3.1 $\Omega_m = \frac{\rho_m}{\rho_c}$, $\Omega_\Lambda = \frac{\rho_\Lambda}{\rho_c}$, $\Omega_b = \frac{\rho_b}{\rho_c}$ $\rho_c = \frac{3H_0^2}{8\pi G}$ H_0 $\Omega_b \approx 0.05$ $\Omega_m \approx 0.31$ $\Omega_\Lambda \approx 0.69$
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 3.2.1 $\lambda_J = \sqrt{\frac{\pi c_s^2}{G\rho}}$ $L > \lambda_J$
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 4.5.1 $R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$
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